Surface Water Assessment Report

Inland Bays Regional Wastewater Facilities
Sussex County, Delaware

January 28, 2019

Prepared for:

Sussex County Engineering Department
Georgetown, Delaware

Prepared by:

Whitman, Requardt & Associates, LLP
Baltimore, MD

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1. Introduction

WRA prepared this Surface Water Assessment Report (SWAR) about the spray irrigation fields at the Inland Bays Regional Wastewater Facilities (IBRWF). The SWAR pertains to potential nutrient impacts. Assessment in the SWAR is based on data from previous investigations, published information, and desktop assessment.

The IBRWF is located approximately 10 miles southwest of Lewes, Delaware. Figure 1 is a map showing the location of the existing and proposed spray areas. A site plan of the existing spray fields is in Appendix 1. Previous WRA reports about the IBRWF are listed in the References section.

The IBRWF began operating in 1992. Currently the IBRWF sprays effluent under State permit LTS 5004-90-12. It has eight spray fields. It is permitted for spraying 2,650,000 gallons per day of treated effluent on 432.5 acres.

The existing fields are located near the wastewater plant, generally north and west of the intersection of Cannon Road and Mt. Joy Road. The existing spray fields have row crops.

The proposed spray fields are located generally west of the wastewater plant, on wooded land. WRA prepared a hydrogeologic report about the spray expansion areas which was dated October 26, 2017.

2. Geologic Setting

WRA obtained information from the geologic publications listed in the References. The IBRWF is located in the Atlantic Coastal Plain region, which has a southeastward-thickening wedge of sand, silt and clay that rests on bedrock more 6,000 feet below the land surface. The shallowest aquifer is the unconfined aquifer, which exists in sediments of the Columbia Group.

The unconfined aquifer receives recharge from precipitation, transmits water to deeper aquifers, and maintains stream flow. The regional base of the unconfined aquifer is the base of the Beaverdam Formation, at a depth of approximately 120 feet.

3. Watersheds

A watershed is defined as all of the land that water moves across or under, while flowing to a specific body of water. Figure 2 is a watershed map obtained from the State website, delawarewatersheds.org.

The IBRWF is located within the Inland Bays watershed, which occupies the southeastern part of the State of Delaware. Within the Inland Bays watershed, a sub-watershed boundary extends through the IBRWF along an approximately northwestern-trending line.

Northeast of the aforementioned sub-watershed boundary is the Rehoboth Bay sub-watershed. Southwest of the boundary is the Indian River sub-watershed.

4. Ambient Groundwater Quality

State regulations for the SWAR indicate that information on ambient groundwater quality is required. Concentrations are available for the following parameters: total phosphorus, total nitrogen, and dissolved oxygen.

WRA assembled the available groundwater quality data provided by Sussex County. Appendix 2 contains tables of the data. The groundwater quality data is from sampling of monitoring wells at the existing and proposed spray fields, by Sussex County. The monitoring wells have screens in the unconfined aquifer.

The groundwater quality data for the existing spray fields consists of quarterly results for the period 2011 to 2015. This data is from twenty-three or twenty-four monitoring wells (depending on the chemical parameter). The WRA January 30, 2017 report contains information about the construction and locations of the monitoring wells at the existing spray fields.

The groundwater quality data for the proposed spray fields is from three rounds of sampling in 2018. This data is from seventeen (of the total twenty-six) monitoring wells located at the proposed spray areas. The WRA October 26, 2017 report contains information about the construction and locations of the monitoring wells at the spray expansion sites.

Table 1 is a summary of the ambient groundwater quality data for total nitrogen.

Table 1: Ambient Total Nitrogen Concentrations in Groundwater

Spray area	Years sampled	Number of data reported	Lowest reported (mg/l)	Highest reported (mg/l)	Average (mg/l)
Existing	2011 to 2015	274	0.13	112.7	13
Proposed	2018	51	< 0.15	2.3	0.2

Table 2 is a summary of the ambient groundwater quality data for total phosphorus.

Table 2: Ambient Total Phosphorus Concentrations in Groundwater

Spray area	Years sampled	Number of data reported	Lowest reported (mg/l)	Highest reported (mg/l)	Average (mg/l)	Percentage of values > 0.034 mg/l
Existing	2011 to 2015	421	< 0.05	95.7	0.3	50 %
Proposed	2018	51	< 0.05	0.06	0.055	4 %

Table 3 is a summary of the ambient groundwater quality data for dissolved oxygen.

Table 3: Ambient Dissolved Oxygen Concentrations in Groundwater

Spray area	Years sampled	Number of data reported	Lowest reported (mg/l)	Highest reported (mg/l)	Average (mg/l)	Percentage of values < 1.0 mg/l
Existing	2012 to 2015	322	0.82	11.01	6	2 %
Proposed	2018	51	2.15	8.32	5	0 %

5. Lysimeter Data

Lysimeters obtain samples of percolate, which is water infiltrating through the unsaturated zone above a water table. Sussex County provided water quality data from four lysimeters. Table 4 is a summary of the total nitrogen data from the lysimeters for the period 2012 to 2018.

Table 4: Total Nitrogen Concentrations in Lysimeter Samples

Existing Spray Areas	Years sampled	Number of data reported	Lowest reported (mg/l)	Highest reported (mg/l)	Average (mg/l)
North Burton field, South Burton field, North Hetti Lingo field, and East Hetti Lingo field	2012 to 2018	93	< 0.13	106.44	12

6. Phosphorus Assessment

State regulations for the SWAR indicate that background soil testing for total phosphorus is required for either Fertility Index Value (FIV), or Mehlich 3 value. Mehlich 3 data is available from the 2016 soils report by Accent Environmental, LLC. Table 5 is a summary of the data.

Table 5: Mehlich 3 Phosphorus Concentrations in Soil

Spray area	Year sampled	Number of data reported	Lowest reported (ppm)	Highest reported (ppm)	Average (ppm)	Percentage of values > 100 ppm
Proposed	2016	42	2	85	17	0 %
Note: Data is from the Accent Environmental, LLC, December 5, 2016 Soil Investigation Report, for Inland Bays Wastewater Treatment Expansion. Data in parts per million (ppm).						

State regulations for the SWAR indicate that phosphorus fate and transport evaluation is required when both of the following conditions are met:

- a FIV > 100, or soil test value > 100 ppm by Mehlich 3 test;
- Groundwater total phosphorus concentrations are > 0.034 mg/L and indicate reducing conditions due to a low dissolved oxygen concentration, < 1 mg/L, or an oxidation-reduction potential < 200 mV.

As indicated in Table 5, none of the available Mehlich 3 values exceed 100 ppm phosphorus in soil at the spray expansion sites. As indicated in Table 2, approximately 50% of the phosphorus values for groundwater exceeded 0.034 mg/l at the existing spray fields (and 4% at the spray expansion sites). Table 3 indicates that 2% of the dissolved oxygen concentrations in groundwater were less than 1 mg/l at the existing fields (and none were less than 1 mg/l at the spray expansion sites).

Based on the reported concentrations for phosphorus in soil and groundwater, and the reported dissolved oxygen data, a transport analysis for phosphorus is not required. In general, dissolved phosphorus has low mobility in groundwater, because it is readily absorbed onto soil.

7. Nitrogen Assessment

State regulations for the SWAR request an analysis of surface water impact with respect to nitrogen. WRA performed a desktop assessment of the nitrogen loading at the IBRWF.

The existing IBRWF spray irrigation fields are located within a region in which the groundwater quality has been negatively impacted for decades by agricultural land use. For example, in their Delaware Agricultural Experiment Station report, Ritter and Chirnside (1982) identified the Fairmount, Delaware area, which includes the existing IBRWF spray fields, as having known nitrate contamination.

Currently the annual nitrogen load to the Inland Bays watershed, contributed by the existing IBRWF spray irrigation fields, is approximately 17.6 tons of nitrogen per year. This is based on analysis of monthly metered effluent flows, and monthly effluent water quality data from 2011 to 2015, which were documented in the WRA January 30, 2017 report. The annual average rate of effluent spraying was 0.72 million gallons per day, on the permitted 432.5 acres. The average concentration of nitrogen in the effluent was 16 mg/l.

The existing IBRWF spray fields have row crops such as corn. Nitrogen is also added to the system by fertilizers used to grow crops. Further, nitrogen is removed from the system by crop uptake. Within the context of an annual average analysis, the load added by fertilizer, and the load subtracted by crop uptake, approximately cancel at the existing spray fields. Nitrogen fertilizer rates for growing corn, and the nitrogen uptake rates by corn, are both reported by various sources in the range of 100 to 200 pounds per acre per year.

The average total nitrogen concentration in the percolate at the IBRWF spray fields is approximately 12 mg/l, based on the data in Table 4. The average 12 mg/l in the percolate is similar to the 13 mg/l average in groundwater at the existing spray fields.

WRA estimated the theoretical total nitrogen concentration in the percolate. The concentration is the load of nitrogen divided by the volume of water. The volume equals the amount of sprayed effluent, plus precipitation, and reduced by potential evapotranspiration (PET). (We used onsite precipitation data from the WRA January 30, 2017 report, and a PET estimate from the WRA November 27, 2006 WRA report.) The theoretical total nitrogen concentration in the percolate is approximately 8 mg/l, which is relatively similar to the average actual 12 mg/l value.

Sussex County plans to develop an additional 2 mgd of disposal capacity at the IBRWF, by spraying effluent on wooded land located generally west of the existing spray fields. The proposed spray areas are on approximately 443 acres. The expansion sites are described in the WRA October 26, 2017 report.

The annual nitrogen load to the Inland Bays watershed associated with the proposed 2 mgd is approximately 48.5 tons per year. This assumes similar effluent quality, and no fertilizer use. Much of this nitrogen load could theoretically be consumed by trees. The uptake rate for southern, loblolly pine is approximately 250 pounds of nitrogen per acre per year, according to the EPA Land Treatment Manual (2006). The average total nitrogen concentration currently in groundwater at the spray irrigation expansion sites is 0.2 mg/l, which is relatively low.

8. Advection-Dispersion Analysis

WRA performed a desktop advection-dispersion assessment of nitrogen transport in the unconfined aquifer. Advection is the process by which moving groundwater carries with it dissolved solutes. Dispersion is the process that acts to dilute the solute and lower its concentration in an aquifer. Nitrate (a form of nitrogen occurring in groundwater) is not readily absorbed. Therefore nitrate is generally carried in moving groundwater.

The methods used in this section of the SWAR are based on a one-dimensional analytical groundwater flow and contaminant transport equation, and associated simplifying hydraulic assumptions about the unconfined aquifer. The analysis uses assumed input values for hydrogeologic parameters, where those parameters were not field-measured. It relies on existing data from previous reports, and did not encompass new field subsurface investigations or water sampling at locations such as offsite streams or domestic wells.

Groundwater in the unconfined aquifer at the existing IBRWF spray irrigation fields and proposed spray fields C and D flows generally east to southeast, based on water table mapping in the WRA October 26, 2017 report. This groundwater flow is toward Guinea Creek, which is approximately 4,000 feet from the existing spray fields (on Figure 1). Agricultural ditches located between the spray fields and the creek might also capture groundwater.

Based on the 2017 water table mapping, groundwater in the unconfined aquifer at proposed spray areas A and B flows east to southeast toward Swan Creek. At its closest distance, the channel of the creek is approximately 600 feet away from the studied spray site. The floodplain of the Swan Creek is an estimated 400 feet away from the studied spray area.

Domestic water wells are located hydraulically downgradient of the IBRWF spray fields, as documented in the site plan accompanying the WRA October 26, 2017 report. A group of twenty-four domestic wells (along Maryland Camp Road and Mt. Joy Road) is located generally southeast of proposed spray irrigation area D. A group of twenty-seven domestic wells (along Miller Street and Mt. Joy Road) is located generally southeast and south of proposed spray area A.

WRA used a one-dimensional advection-dispersion equation to theoretically assess the movement of nitrate in the unconfined aquifer at the IBRWF. The advection-dispersion equation predicts the concentration of a contaminant in an aquifer, at a location downgradient of a contaminant source, after various times of transport. Within hydraulic assumptions, a hypothetical continuous contaminant source in an aquifer causes a plume of contaminants to be formed. A potential contaminant plume would tend to be elongated in the longitudinal direction, i.e., in the direction of groundwater flow.

Input data required for the advection-dispersion equation include an estimate of the initial contaminant concentration; the hydraulic gradient (i.e., the slope of the water table); the porosity of the aquifer material; and the hydraulic conductivity of the aquifer material, which depends on how permeable it is. The equation also requires an estimate of the scale of a contaminant plume; and a parameter called longitudinal dispersivity, which has the units of length. In general, the value of the longitudinal dispersivity tends to increase with the scale of a plume.

The advection-dispersion analysis assumes that the initial contaminant concentration is 12 mg/l, which is the average of the lysimeter percolate data for total nitrogen. It assumes a hypothetical plume length of 400 feet, for assessing transport toward domestic water wells and a stream floodplain.

The analysis assumes that the porosity is 0.2, and the hydraulic conductivity is 200 feet per day, which are representative values for sand, the principal component of the unconfined aquifer. The hydraulic gradient is input as 0.003 based on the available water table mapping.

The longitudinal dispersivity is assumed to be approximately 16 feet, based on computation as a function of hypothetical plume scale.

Table 6 contains the results of the advection-dispersion calculations. It provides estimated contaminant concentrations in the unconfined aquifer, at the distance of 400 feet at various times.

Table 6: Advection-Dispersion Data

Time (days)	Concentration (mg/l)
30	0.0
60	0.0
90	1.0
120	4.3
150	7.9
180	10.3
210	11.4
240	11.8
270	11.9
300	12.0

Under the previously described idealized hydraulic assumptions and assumed aquifer properties, the analysis summarized in Table 6 estimated that in approximately three months, the downgradient concentration of the contaminant would be approximately 1 mg/l. It estimated that in approximately six months, the concentration would slightly exceed 10 mg/l, which is the drinking water standard for nitrate. Also the downgradient concentration would theoretically be similar to the assumed initial concentration (12 mg/l) in approximately ten months. In actual conditions, mixing of percolate and existing groundwater would occur.

9. Conclusion

WRA prepared a Surface Water Assessment Report for Sussex County, Delaware, about nutrient impacts related to the effluent disposal spray irrigation fields at the Inland Bays Regional Wastewater Facilities. The existing and proposed spray areas are located within the Inland Bays Watershed. The current annual average spray rate is approximately 0.7 million gallons per day.

Based on groundwater quality and soil phosphorus data, a transport analysis for phosphorus is not required. The spray fields are located in an area with a history of elevated nitrate concentrations in the unconfined aquifer. Domestic water wells are located hydraulically downgradient of spray fields. Sussex County plans to develop an additional 2 million gallons per day of spray irrigation disposal capacity on wooded land located west of the existing spray fields.

10. References

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Figures

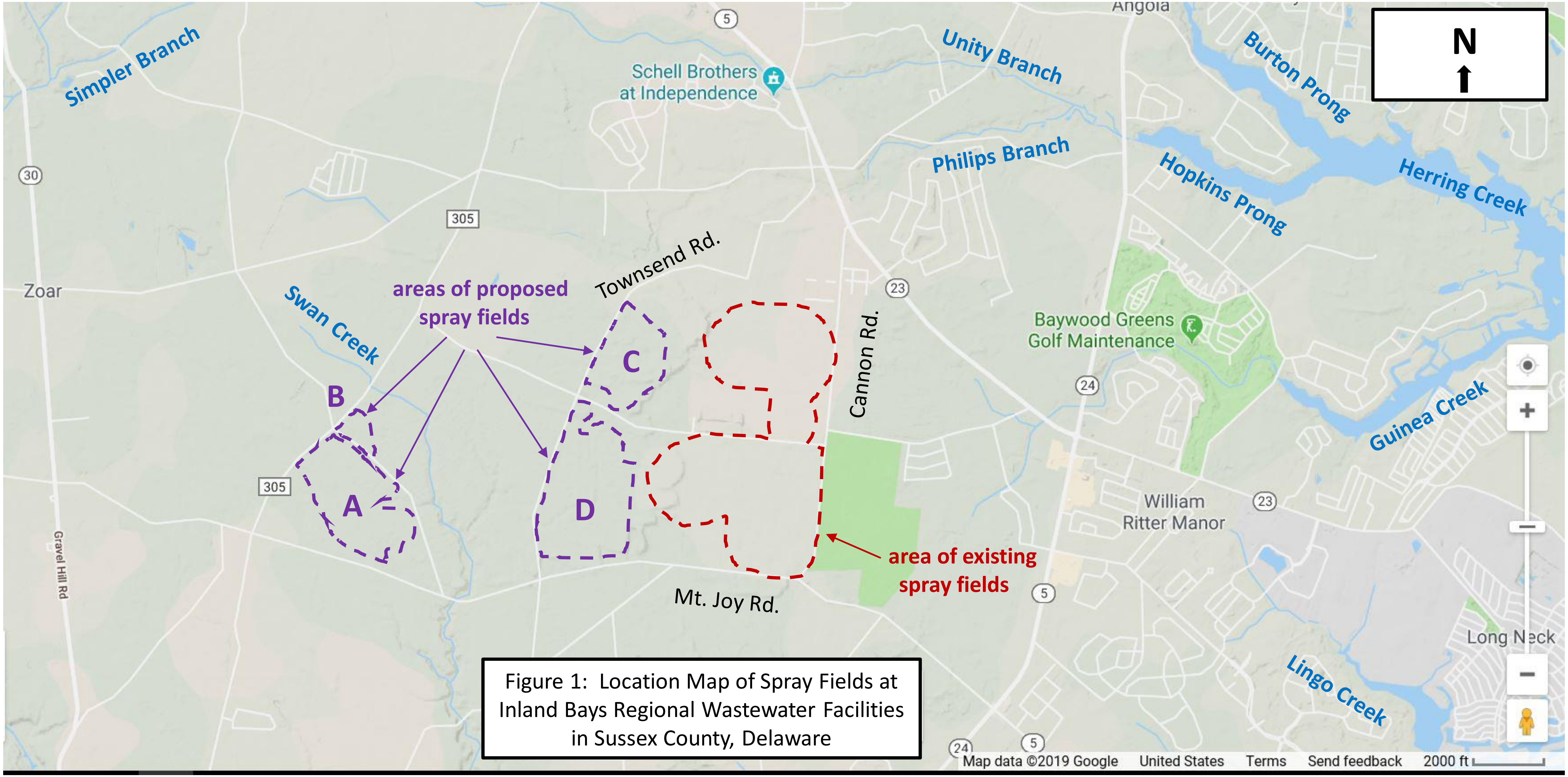


Figure 1: Location Map of Spray Fields at Inland Bays Regional Wastewater Facilities in Sussex County, Delaware

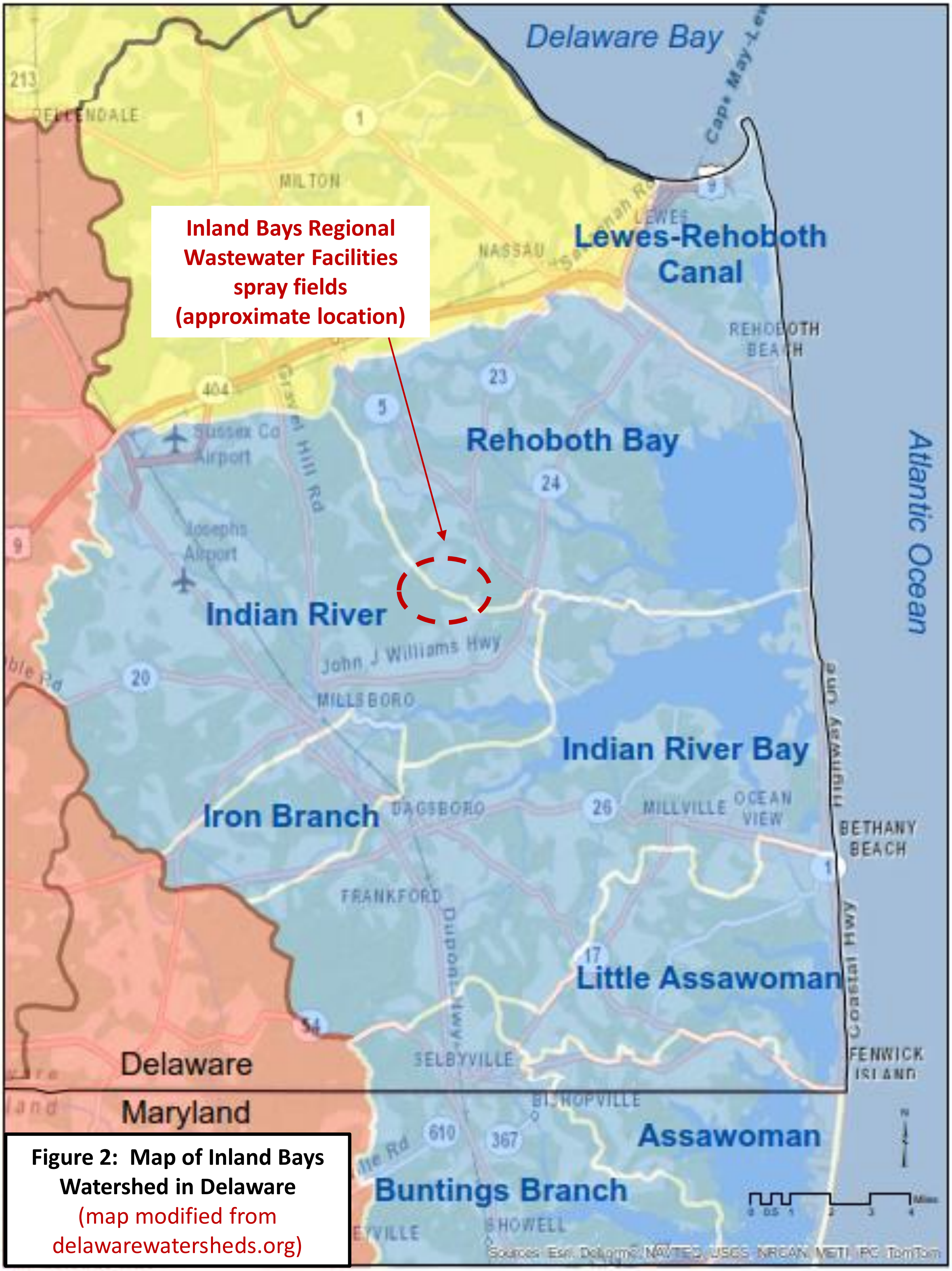
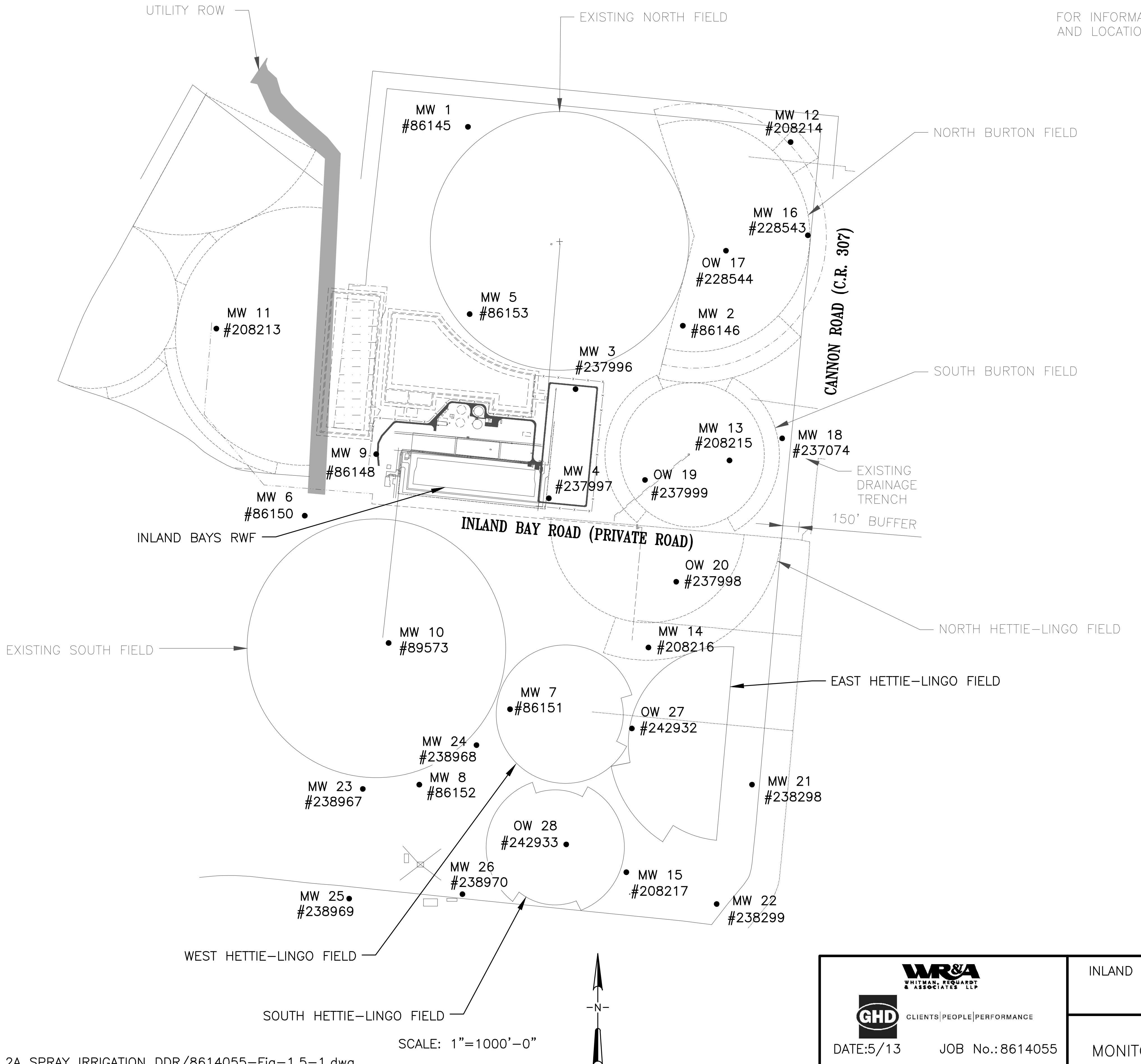


Figure 2: Map of Inland Bays Watershed in Delaware
(map modified from delawarewatersheds.org)

Appendix 1

Site Plan of Existing Spray Fields

FOR INFORMATIONAL PURPOSES ONLY ALL BOUNDARIES AND LOCATIONS ARE APPROXIMATE



• LOCATION OF MONITORING AND OBSERVATION WELLS

0 500' 1000' 2000'

SCALE: 1" = 1000'-0"

WR&A WHITMAN, REQUARDT & ASSOCIATES LLP

GHD CLIENTS|PEOPLE|PERFORMANCE

DATE:5/13 JOB No.:8614055

INLAND BAYS REGIONAL WASTE WATER FACILITY DESIGN DEVELOPMENT REPORT

FIGURE 1.5–1
MONITORING AND OBSERVATION WELLS

G:/86/14055/WORDPROC/REPORTS/PHASE 2A SPRAY IRRIGATION DDR/8614055–Fig–1.5–1.dwg

Appendix 2

Groundwater Quality Data

Total Nitrogen (mg/l)

existing fields

	Q1-2011	Q2-2011	Q3-2011	Q4-2011	Q1-2012	Q2-2012	Q3-2012	Q4-2012	Q1-2013	Q2-2013	Q3-2013	Q4-2013	Q1-2014	Q2-2014	Q3-2014	Q4-2014	Q1-2015	Q2-2015	Q3-2015	Q4-2015
MW-1							2.18	1.53		0.65	1.15		0.85	0.87		0.67	0.85	1.62	1.21	0.94
MW-2							6.73	23.70		25.50	16.30		13.10	14.59		9.22	7.34	13.13	12.70	10.40
MW-3							10.30	9.85	9.24	9.46	8.22		8.28	10.20		11.75	10.00	7.45	5.27	4.96
MW-4							4.08	4.24	4.31	4.83	5.42		7.95	7.70		5.97	6.44	6.71	6.54	5.98
MW-5							1.40	3.14	4.38	1.47	2.73		3.43	1.09		0.96	0.86	0.64	0.52	1.16
MW-6							2.20	1.37	0.40	0.13	0.64		0.87	1.00		1.97	1.04	1.18	1.69	1.78
MW-7							7.63	1.14	11.80	1.85	9.08		5.81	4.90		4.34	4.70	4.44	4.81	5.24
MW-8							20.10	16.00	19.10	23.30	20.10		26.30	36.82		22.29	17.33	14.86	14.83	13.25
MW-9							1.56	0.52	0.38	0.89	2.41		1.12	1.13		0.51	1.29	1.30	4.50	1.23
MW-10							11.90	11.30	8.75	4.57	3.02		6.07	7.05		7.74	7.74	10.24	9.40	6.00
MW-11							2.57	2.56	2.42	2.24	1.98		1.71	1.58		1.84	1.70	1.62	1.69	1.73
MW-12							17.80	20.80	44.50	35.00	24.40		12.72	15.52		17.14	13.75	23.00	45.40	24.90
MW-13							15.80	3.48	1.96	16.50	21.50		4.95	4.93		5.57	5.96	4.21	6.06	6.58
MW-14							10.10	5.33	3.71	1.00	2.53		22.38	9.97		7.83	13.83	10.53	10.37	11.10
MW-15							23.70	23.80	27.40	31.90	27.40		29.63	27.28		28.84	21.01	27.32	31.70	33.50
MW-16							17.90	31.10	24.40	10.50	8.12		4.66	9.46		36.79	75.88	34.89	17.24	13.80
OW-17																				
MW-18							9.64	9.24	9.77	9.15	4.33		3.68	8.03		17.35	11.11	6.46	4.20	3.49
OW-19																				
OW-20																				
MW-21							11.40	11.20	12.20	14.00	12.90		13.05	15.20		14.25	14.60	14.23	14.10	13.80
MW-22							13.70	12.20	3.53	10.90	11.90		12.05	15.78		23.55	19.47	18.20	16.80	18.90
MW-23							9.44	7.34	3.53	2.63	1.06		0.45	0.33		0.56	1.50	1.52	1.81	1.26
MW-24							22.40	22.00	36.40	14.50	36.70		109.23	108.11		112.70	103.10	94.05	48.04	35.90
MW-25							8.80	14.70	11.90	9.01	14.00		23.67	29.89		12.23	16.80	12.02	11.02	9.95
MW-26							13.30	11.50	14.00	11.30	11.80		18.01	18.02		25.27	17.78	9.18	7.21	8.29

Phosphorus as P (mg/l)

existing fields

	Q1-2011	Q2-2011	Q3-2011	Q4-2011	Q1-2012	Q2-2012	Q3-2012	Q4-2012	Q1-2013	Q2-2013	Q3-2013	Q4-2013	Q1-2014	Q2-2014	Q3-2014	Q4-2014	Q1-2015	Q2-2015	Q3-2015	Q4-2015
MW-1	0.05	0.05	0.05	0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
MW-2	0.18	0.05	0.05	0.056	<0.05	0.092	0.28	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.05	0.05	0.05	0.05
MW-3					<0.05	<0.05	<0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
MW-4					<0.05	<0.05	<0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.07	0.05	0.05	0.05	0.05	0.05	0.05
MW-5	0.91	0.28	0.32	1.37	0.505	<0.05	1.28	0.26	0.48	1.17	1.78	0.33	0.36	0.52	0.99	0.47	0.46	1.12	1.04	0.31
MW-6	0.05	0.05	0.05	0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.05	0.05	0.05	0.05	0.05	0.05
MW-7	0.056	0.056	0.05	0.49	<0.05	0.051	<0.05	0.05	1.42	0.05	0.14	0.05	0.63	0.05	0.05	0.08	0.05	0.05	0.05	0.05
MW-8	0.051	0.05	0.05	0.05	<0.05	<0.05	<0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.09	0.05	0.08	0.05	0.05	0.05	0.05
MW-9	0.077	0.38	0.189	0.28	<0.05	0.61	0.19	0.2	0.09	0.24	1.11	0.16	0.29	0.33	0.11	0.12	0.63	0.37	0.5	0.11
MW-10	0.067	0.43	0.15	0.1	0.051	0.087	0.08	0.09	0.1	0.07	0.09	0.09	0.07	0.17	0.05	0.12	0.05	0.05	0.05	0.05
MW-11			<.05	0.05	<0.05	<0.05	<0.05	<.05	0.05	<.05	<0.05	< 0.05	<0.05	0.15	<.05	0.48	<0.05	0.07	0.12	<0.05
MW-12	< .05	< .05	<.05	0.05	<0.05	<0.05	<0.05	<.05	<.05	<.05	<0.05	< 0.05	<0.05	<0.05	95.7	<0.05	<0.05	<0.05	<0.05	<0.05
MW-13	0.11	< .05	<.05	0.05	<0.05	<0.05	0.068	0.32	0.6	0.46	0.46	0.25	0.45	0.66	0.3	0.19	0.18	0.38	<0.05	<0.05
MW-14	< .05	< .05	0.06	0.058	<0.05	<0.05	<0.05	<.05	<.05	<.05	<0.05	< 0.05	<0.05	0.08	<.05	0.08	<0.05	<.05	<0.05	<0.05
MW-15	0.15	< .05	<.05	0.05	<0.05	<0.05	<0.05	<.05	<.05	<.05	0.09	< 0.05	<0.05	<0.05	<.05	0.06	<0.05	<0.5	<0.05	<0.05
MW-16	< .05	< .05	0.18	0.097	<0.05	<0.05	<0.05	<.05	<.05	<.05	<0.05	< 0.05	<0.05	<0.05	<.05	<0.05	<0.05	<0.05	<0.05	<0.05
OW-17	0.051	< .05	0.11	0.05	<0.05	<0.05														
MW-18					<0.05	<0.05	<0.05	<.05	<.05	<.05	<0.05	< 0.05	<0.05	<0.05	<.05	<0.05	<0.05	<0.05	<0.05	<0.05
OW-19																				
OW-20																				
MW-21						<0.05	<0.05	<.05	0.06	<.05	<0.05	< 0.05	<0.05	<0.05	<.05	<0.05	<0.05	<0.05	<0.05	<0.05
MW-22						<0.05	<0.05	<.05	<.05	<.05	<0.05	< 0.05	<0.05	0.1	<.05	<0.05	<0.05	<0.05	<0.05	<0.05
MW-23						<0.05	<0.05	<.05	<.05	<.05	<0.05	< 0.05	<0.05	0.1	<.05	<0.05	<0.05	<0.05	<0.05	<0.05
MW-24						<0.05	<0.05	<.05	<.05	<.05	<0.05		<0.05	0.11	<.05	<0.05	<0.05	<0.05	<0.05	<0.05
MW-25						<0.05	<0.05	<.05	<.05	<.05	<0.05	< 0.05	<0.05	0.13	<.05	<0.05	<0.05	<0.05	<0.05	<0.05
MW-26						<0.05	<0.05	<.05	<.05	<.05	<0.05	< 0.05	<0.05	0.12	<.05	0.05	<0.05	<0.05	<0.05	<0.05

Dissolved Oxygen (mg/l)

existing fields

	Q1-2011	Q2-2011	Q3-2011	Q4-2011	Q1-2012	Q2-2012	Q3-2012	Q4-2012	Q1-2013	Q2-2013	Q3-2013	Q4-2013	Q1-2014	Q2-2014	Q3-2014	Q4-2014	Q1-2015	Q2-2015	Q3-2015	Q4-2015
MW-1							6.16	7.37	6.28	7.99	4.79	4.22	3.91	6.61	5.51	5.6	6.94	5.68	4.84	4.36
MW-2							6.63	7.99	6.64	9.96	4.43	4.17	4.88	6.71	5.62	5.36	6.01	4.03	3.66	4.95
MW-3							5.26	5.51	7.23	6.98	5.59	3.81	4.81	8.02	7.47	7.54	7.83	6.93	7.39	7.65
MW-4							3.56	4.46	5.76	4.78	3.42	2.68	2.58	5.79	4.01	4.74	4.11	3.4	3.71	4.31
MW-5							0.82	8.26	7.08	7.04	1.97	2.96	2.98	1.98	2.55	2.93	3.79	2.42	2.14	3.26
MW-6							6.53	7.33	8.63	7.84	3.21	3.52	5.03	5.61	6.87	7.04	7.41	6.06	7.36	7.31
MW-7							2.81	2.83	2.45	3.34	1.82	1.49	2.85	1.31	2.74	2.25	2.99	3.19	1.77	1.91
MW-8							7.35	8.13	10.85	10.29	7.65	5.17	6.46	9.46	8.62	9.22	10.23	9.01	8.51	8.81
MW-9							3.43	2.12	3.95	2.95	3.66	4.67	4.97	1.16	1.55	5.79	5.51	1.57	3.19	3.56
MW-10							2.78	5.02	6	3.33	1.96	2.04	1.62	4.42	1.88	4.35	3.51	2.55	1.72	1.74
MW-11							6.82	7.89	10.86	8.22	5.22	3.65	4.11	7.63	5.4	8.28	8.43	6.9	8.29	8.73
MW-12							7.71	8.34	7.4	10.19	5.83	5.79	5.33	8.35	6.63	7.57	9.35	6.72	7.39	7.47
MW-13							6.91	8.05	7.17	8.22	4.28	4.57	4.53	5.43	3.65	4.69	5.85	4.16	2.79	4.85
MW-14							6.64	5.83	7.27	11.01	7.67	5.42	5.45	6.96	5.91	5.67	7.08	4.1	2.74	2.29
MW-15							6.53	7.97	9.77	9.46	5.92	4.98	5.47	7.62	6.81	7.16	9.64	6.4	6.83	8.01
MW-16							6.93	8.22	6.75	9.89	4.97	3.86	3.62	5.37	4.46	3.53	4.63	3.4	3.65	3.69
OW-17																				
MW-18							7.47	8.11	7.05	9.14	7.26	4.65	5.55	9.36	8.02	7.59	7.54	6.13	5.66	5.13
OW-19																				
OW-20																				
MW-21							4.74	6.01	8.44	7.97	5.81	3.95	4.41	6.07	6.58	2.29	6.74	6.17	5.82	5.77
MW-22							4.78	6.38	6.55	9.19	7.44	5.42	4.99	8.07	7.89	7.5	8.08	7.61	7.11	6.56
MW-23							2.58	6.02	8.99	9.69	8.49	3.41	3.97	4.14	4.36	5.25	4.47	3.23	2.43	2.96
MW-24							6.18	5.88	9.27	6.37	7.57	4.24	5.12	6.43	4.27	2.33	4.52	2.15	2.59	2.74
MW-25							7.38	8.24	9.89	9.92	7.85	5.36	5.85	9.43	8.12	7.58	9.35	7.67	7.41	7.49
MW-26							7.6	8.51	12	10.21	8.17	5.46	6.62	9.95	8.89	8.6	10.28	8.51	8.2	8.53

Total Nitrogen (mg/l)			
proposed fields			
	March 2018	April 2018	May 2018
MW-10	<0.37	<0.43	<0.26
MW-11	<0.34	<0.82	<0.25
MW-12	<0.26	<0.55	<0.30
MW-13	<0.29	<0.68	<0.27
MW-14	0.89	2.3	0.863
MW-15	<0.33	<0.59	<.15
MW-16	<0.36	<0.77	<.25
OW-17	1.51	1.33	1.4
MW-18	<0.23	<0.32	<.25
OW-19	<0.34	<0.35	<.35
OW-20	0.27	0.38	0.68
MW-21	<0.28	<0.30	<.25
MW-22	<0.42	<0.25	<.28
MW-23	<0.25	<0.27	<.25
MW-24	<0.40	<0.29	<.27
MW-25	<0.28	<0.55	<.29
MW-26	<0.32	<0.32	<.60

Total Phosphorus (mg/l)			
proposed fields			
	March 2018	April 2018	May 2018
MW-10	<0.05	<0.05	<0.05
MW-11	<0.05	<0.05	<0.05
MW-12	<0.05	<0.05	<0.05
MW-13	<0.05	<0.05	<0.05
MW-14	<0.05	<0.05	<.05
MW-15	<0.05	<0.05	<.05
MW-16	<0.05	<0.05	<.05
OW-17	<0.05	<0.05	<.05
MW-18	0.05	<0.05	<.05
OW-19	<0.05	<0.05	<.05
OW-20	<0.05	<0.05	<.05
MW-21	<0.05	<0.05	<.05
MW-22	<0.05	<0.05	<.05
MW-23	<0.05	<0.05	<.05
MW-24	<0.05	<0.05	<.05
MW-25	<0.05	<0.05	<.05
MW-26	<0.05	<0.05	0.06

Dissolved Oxygen (mg/l)			
proposed fields			
	March 2018	April 2018	May 2018
MW-10	4.02	2.62	2.15
MW-11	5.2	4.27	4.5
MW-12	4.00	3.92	2.82
MW-13	5.96	4.99	4.81
MW-14	4.94	3.79	2.96
MW-15	4.31	3.94	4.04
MW-16	8.32	7	6.6
OW-17	7.17	6.18	5.34
MW-18	5.22	4.93	4.85
OW-19	4.88	5.45	5.35
OW-20	4.09	3.39	3.02
MW-21	4.45	4.08	3.31
MW-22	4.72	4.13	3.27
MW-23	4.37	5.78	3.97
MW-24	4.79	4.14	3.76
MW-25	7.24	5.48	5.71
MW-26	2.92	2.42	2.61

Appendix 3

Lysimeter Data

Total Nitrogen concentrations (mg/l) in lysimeter samples
Sussex County, DE - Inland Bays spray irrigation fields

year	month	South Burton	North Hetti Lingo	North Burton	East Hetti Lingo
2012	Sept.	16.2	31	x	x
2012	Dec.	6.75	32	1.55	x
2013	March	1.3	14.9	0.57	x
2013	June	0.53	20.7	1.24	26
2013	Sept.	1.59	6.08	2.93	41.9
2013	Dec.	5.36	24.5	2.82	13.6
2014	March	2.67	1.36	2.53	6.08
2014	June	2.47	6.19	2.53	5.45
2014	Sept.	12.07	10.28	14.96	6.49
2014	Dec.	6.66	23.76	1.83	1.84
2015	March	3.91	8.42	1.51	2.53
2015	June	6.61	8.03	4.71	35.72
2015	Sept.	7.04	4.97	4.58	27.56
2015	Dec.	4.29	19.3	6.07	5.73
2016	March	7.34	15.86	6.25	2.06
2016	June	x	x	x	x
2016	Sept.	65.96	17.42	106.44	3.04
2016	Dec.	8.61	26.36	8.94	16.16
2017	March	6.31	8.18	2.99	1.582
2017	June	1.228	6.87	2.02	22.53
2017	Sept.	27.89	92.64	15.24	7.7
2017	Dec.	15.5	24.4	6.48	x
2018	March	7.94	x	1.93	x
2018	June	1.03	2.52	1.54	5.44
2018	Sept.	36.7	3.31	7.99	9.73
2018	Dec.	1.73	1.985	2.64	1.43